

Natural Sciences 102 -- Spring 2005
Exam #1 **April 21, 2005**

Name:

For TA use only:

1 (5)	2 (20)	3 (10)	4 (10)	5 (10)	6 (10)	7 (10)	(75)

General instructions:

- For essay and descriptive questions, please be complete, but concise. Answers should be limited to the space provided under the question.
- For this exam calculators are not necessary, but if you wish to hold one in your hand, it must be one of the ones provided....not your personal calculator.
- Values of the various problems are indicated.

I. Hypothesis: [5pts]

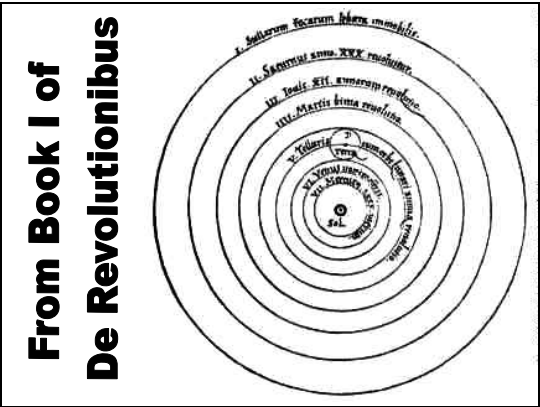
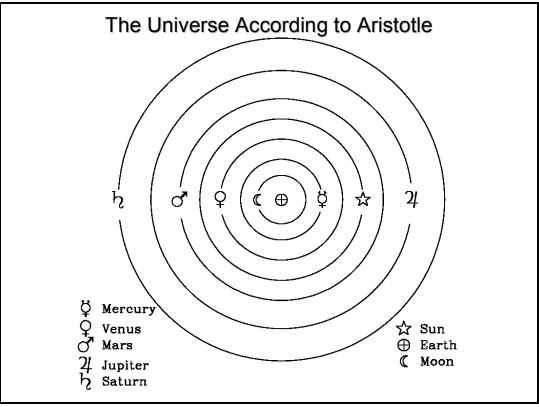
Contrast the modern use of the word “hypothesis” [a proposition or theory assumed as a basis for reasoning, argument, or investigation] with how the word was originally used in astronomy.

The ancient Greeks introduced the work hypothesis to mean something that was introduced to “*save the appearances.*”

It was introduced after the fact in order to reconcile observation with the theory. It was not necessarily thought to be true. In fact whether it was true or not was irrelevant. All that mattered is that it worked.

A good example of a hypothesis is the epicycle. It was a hypothesis in the sense that it was introduced as a mechanism by which the observations of retrograde motion of the planets could be reconciled with the Aristotelian arrangement of the universe.

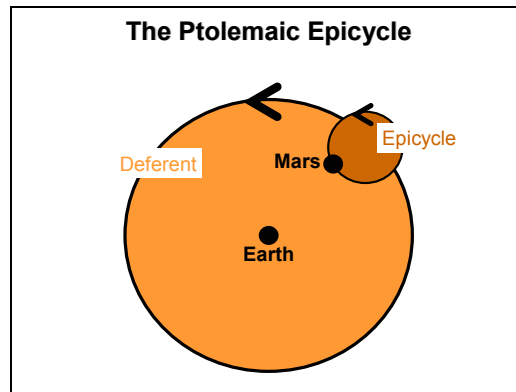
II. The Two Chief World Systems: [20pts]

Question	Copernican	Ptolemaic
Illustrate the arrangement of the model by means of a diagram.	<p>From Book I of De Revolutionibus</p>  <p>Should also indicate epicycles.</p>	<p>The Universe According to Aristotle</p>  <p>Should also indicate epicycles.</p>
Cosmological models are part of a larger intellectual framework. Describe the factors (physics, philosophy, etc.) that influenced the development of the models.	<p>Some factors:</p> <ul style="list-style-type: none"> i) The renaissance led to the idea that people could rethink the ideas of antiquity. ii) Copernicus was interested in the aesthetics of a cosmological model. iii) Over the centuries since Ptolemy the differences between the model and the observations increased over time. iv) Motions must be circular since circles are “perfect.” 	<p>Some factors:</p> <ul style="list-style-type: none"> i) Based upon the “physics” of Aristotle. ii) Philosophy based. iii) Based upon “sense” – you don’t usually feel Earth move. iv) Motions must be circular since circles are “perfect.” v) Things in the heavens are perfect. Stars and planets are made of quintessence. vi) Different laws apply to the heavens.
What were the distinguishing characteristics of the model?	<p>Some distinguishing characteristics:</p> <ul style="list-style-type: none"> i) Sun is the center of motions. ii) Earth moves iii) Planets move in circular orbits iv) Uniform velocities v) Epicycles 	<p>Some distinguishing characteristics:</p> <ul style="list-style-type: none"> i) The Earth is the center of motions. ii) Earth is at rest. iii) Planets move in circular orbits iv) Uniform velocities v) Epicycles

III. Epicycles [10pts]:

- a) [4pts] What is an epicycle? A drawing would be useful.

An epicycle is a geometric construction that was introduced to explain the variations in speed and direction of the apparent motion of the (moon stars, and) planets (as well as the moon and stars. In particular it was introduced to explain retrograde motion of the planets. It is the quintessential example of something that was introduced to “save the appearances.” It was a hypothesis.



- b) [4pts] Describe the problem that led to the introduction of epicycles? Explain how epicycles were able to solve the problem.

The problem was retrograde motion of the planets. Planets (from the Greek word for *wanderer*) mostly travel in a eastward direction across the fixed stars, but occasionally the planet stops its eastward journey and travels westward for a while before stopping again and resuming its eastward journey. The westward motion is called retrograde motion.

As viewed from Earth, planets are observed mostly traveling eastward along the deferent. The added motion of the planet on the epicycle would at times *add* to the apparent motion of the planet as viewed from Earth, and at times subtract from the apparent motion of the planet as viewed from Earth. When subtracting from the eastward motion along the deferent, the planet can appear to be traveling westward in retrograde motion

- c) [2pts] Which of the following cosmological models had epicycles?

- i. Ptolemaic
- ii. Copernican
- iii. Keplerian
- iv. Newtonian

Ptolemaic and Copernican.

IV. Kepler's Laws: [10pts]

a) [5pts] List **and describe** Kepler's Three Laws of Planetary Motion. (It is not necessary that you have the correct numbering; *i.e.*, I just want the three laws, I don't care which is First, Second, or Third.)

1. The planets move in elliptical orbits about the sun with the sun at one focus of the ellipse.
2. The velocity of the planet about the sun is not uniform but changes with time. It changes in such a way that the planet traces out "equal areas in equal times."
3. The third law is a mathematical expression relating the orbital period of the planet to the distance between the sun and the planet, more precisely, to the semimajor axis of the orbit of the planet. The exact expression is that the square of the period is proportional to the cube of the semimajor axis.

b) [5pts] Explain how each of Kepler's laws was a departure from the commonly accepted thought at the time of Kepler.

1. It was thought that the orbits must be circular. Perfect circles.
2. It was believed that the planet always moves with constant velocity.
3. It was not believed that there would be a mathematical expression relating the period and the distance. It was also not believed that the universe was comprehensible to humans.

V. The Telescope: [10 pts]

- a) [5pts] Describe two of Galileo's telescope discoveries that were important in developing his cosmological view.

All of Galileo's telescope discoveries were important for developing his cosmological views.

1. Spots on the Sun
2. Mountains on the moon
3. Phases of Venus
4. Rings of Saturn
5. Stars are distant
6. Stars invisible to the naked eye
7. Milky way made of stars
8. Moons of Jupiter

Example of "description:"

- i) Moons of Jupiter. Galileo discovered that "stars" or "moons" revolve around Jupiter.
- ii) Phases of Venus. Galileo discovered that Venus seems to change shape over time in a regular fashion just like the Moon does (half, crescent, quarter, etc.).

- b) [5pts] For each discovery you chose, please explain why the discovery was important for the development of cosmology.

Moons of Jupiter: This was proof that a body other than Earth was the center for motions.

Phases of Venus: This was proof that the motion or orbit of Venus "must embrace the Sun" (in the words of Galileo in the *Dialogue*).

VI. Galileo: [10pts]

- a) [5pts] From your reading of the passage from Galileo's Dialog, describe one aspect of it and how Galileo used it to advance his position.

There are several possible choices:

- 1) Venus has phases like the moon. This was a result of Galileo's telescope discoveries.
- 2) Same for Mercury.
- 3) Three outer planets (Mars, Jupiter, Saturn) close to the sun when in opposition.
- 4) Outer planets come into opposition to the sun.
- 5) Aristotle's arguments that Earth is stationary depend on the universe having a center.

- b) [5pts] Give an example of a primary effect and a secondary effect for
- i. Galileo's experiments with falling bodies
 - ii. Galileo's theory of the tides

- i) The primary effect was that bodies fall at the same rate independent of their color, mass, composition. An example of a secondary effect is air resistance. The action of the secondary effect accounts for the fact that feathers do not fall at the same rate as rocks.
- ii) The primary effect was that the motion of Earth (its motion about the sun and its rotation) caused the tides, one at noon and the other at midnight. The secondary effect the unevenness of the seafloor which (Galileo reasoned) would explain why the timing was not exactly as predicted.

VII. Extreme Makeover: [10pts]

Describe the approach to understanding nature both before and after the scientific revolution.

Before: Understand nature based on authority---either the authority of the ancients or the authority of scripture. It was also based on philosophy and sense.

After: Understand nature from experiment and observation. Question authority. DO THE EXPERIMENT. Scientific method. Reason conquer sense.